WESLEY COLLEGE

PART 1		50
PART 2		70
PART 3		80
TOTAL		200

YEAR 12 TRIAL EXAMINATIONS 8 OCTOBER 2013

CHEMISTRY

CANDIDATE'S NAME: …….

NAME OF YOUR TEACHER: …….

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten Minutes
Working time for paper: 3 Hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Paper
Separate Chemistry Data Sheet

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser, correction fluid/tape, ruler, highlighters

Special Items: Non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you hand it to the supervisor BEFORE reading any further.

STRUCTURE OF PAPER

Part	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx) /Minutes
1	Multiple choice	25	ALL	50	45
2	Short answer	9	ALL	70	65
3	Extended answers	5	ALL	80	75

Total marks for paper = 200 (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time: The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Parts 2 and 3.

Part 1 – Multiple Choice
Answer ALL questions in Part 1 on the Multiple Choice Answer Sheet by placing a CROSS using a pen in the appropriate box.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will **not** be deducted for incorrect answers. If you need to make a correction make sure your intent is clear. No marks will be awarded if the intent of your answer is not certain.

FEEL FREE TO WRITE OR DO WORKING ON THE QUESTION PAPER; many students who score high marks on the Multiple Choice Section do this.

Parts 2 and 3. Write your answers in this Question/Answer Booklet.
When calculating numerical answers, show your reasoning clearly unless instructed otherwise.

Spare pages are included at the end of the paper. They can be used for planning your responses and/or as additional space if required to continue an answer.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those specific species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^{+}_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $CH_3COOH_{(l)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$, $Na_2CO_{3(s)}$].

SEE NEXT PAGE

PART 1: MULTIPLE CHOICE ANSWER SHEET

YOUR NAME: ……..

INSTRUCTIONS: Using a pen mark your selections on this sheet by using a X. If you need to make a correction make sure you intent is clear.

You may choose to carefully remove this answer sheet

1. [A] [B] [C] [D]
2. [A] [B] [C] [D]
3. [A] [B] [C] [D]
4. [A] [B] [C] [D]
5. [A] [B] [C] [D]
6. [A] [B] [C] [D]
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8. [A] [B] [C] [D]
9. [A] [B] [C] [D]
10. [A] [B] [C] [D]
11. [A] [B] [C] [D]
12. [A] [B] [C] [D]
13. [A] [B] [C] [D]
14. [A] [B] [C] [D]
15. [A] [B] [C] [D]
16. [A] [B] [C] [D]
17. [A] [B] [C] [D]
18. [A] [B] [C] [D]
19. [A] [B] [C] [D]
20. [A] [B] [C] [D]
21. [A] [B] [C] [D]
22. [A] [B] [C] [D]
23. [A] [B] [C] [D]
24. [A] [B] [C] [D]
25. [A] [B] [C] [D]

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PART 1 (50 marks = 25% of paper)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet.

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1. An element, X, was found to have the following successive ionisation energies:

Ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation energy/kJ mol^{-1}	736	1450	7740	10500	13600	18000	21700	25600

Which of the following represents the **most** likely formula for the sulfate of X?

(a) XSO_4
(b) X_2SO_4
(c) $X_2(SO_4)_3$
(d) $X(SO_4)_2$

2. Which of the following bonds would be expected to have the **greatest** polarity?

(a) N–F
(b) P–F
(c) S–F
(d) O–F

3. Carbon, silicon, germanium, tin, and lead are all placed together in the same group of the periodic table because:

(a) They have the same number of valence electrons.
(b) Each has a structural form with delocalized electrons.
(c) Atoms of each element have the same number of electrons.
(d) There is a gradual increase in their atomic masses.

4. The lightest isotope of arsenic is ^{65}As. Which of the following correctly lists the number of subatomic particles in the arsenide ($^{65}As^{3-}$) ion?

(a) 65 protons, 33 neutrons and 68 electrons
(b) 33 protons, 32 neutrons and 30 electrons
(c) 65 protons, 32 neutrons and 65 electrons
(d) 33 protons, 32 neutrons and 36 electrons

SEE NEXT PAGE

5. Place the following substances in order of melting point, starting with the **lowest:**

$Na_2O(s)$, $SO_2(s)$, $O_2(s)$, $CaO(s)$

(a) $SO_2(s)$ $O_2(s)$ $Na_2O(s)$ $CaO(s)$
(b) $SO_2(s)$ $O_2(s)$ $CaO(s)$ $Na_2O(s)$
(c) $O_2(s)$ $SO_2(s)$ $Na_2O(s)$ $CaO(s)$
(d) $O_2(s)$ $SO_2(s)$ $CaO(s)$ $Na_2O(s)$

6. Which of the following statements about the carbonate, nitrate, and sulfite ions is/are **true**?

(i) They are all negatively charged
(ii) They all have the same total number of electrons
(iii) They all have three atoms bonded to the central atom
(iv) They all have the same number of bonding pairs of electrons

(a) (i) and (iii) only
(b) (ii) and (iv) only
(c) (i), (iii) and (iv) only
(d) (i), (ii), (iii) and (iv)

7. Which of the following molecules has a planar shape?

(a) cyclopentene
(b) methanol
(c) methanal
(d) ammonia

8. Predict which of the following has the **greatest** solubility in water.

(a) Propanoic acid
(b) butan-1-ol
(c) Silver iodide
(d) Magnesium phosphate

9. Predict which one of the following aqueous solutions is the **best** conductor of electricity.

(a) 1.00 $molL^{-1}$ ethanoic acid
(b) 1.00 $molL^{-1}$ ammonia
(c) 1.00 $molL^{-1}$ calcium chloride
(d) 1.00 $molL^{-1}$ nitric acid

10. Which of the following solution combinations would produce a green precipitate when mixed together?

(a) NaCl, $Ni(NO_3)_3$, KCH_3COO, $AgNO_3$
(b) $Cr(NO_3)_3$, KCl, Na_2CO_3, NH_4NO_3
(c) NH_4Cl, $NaCH_3COO$, $Ni(NO_3)_2$, $FeCl_2$
(d) $CuSO_4$, $NaNO_3$, KCH_3COO, $CrCl_3$

SEE NEXT PAGE

11. Which of the following contains the **largest** number of <u>atoms</u>?

(a) 6.02×10^{22} molecules of methane
(b) 0.24 mol of argon gas
(c) 12 L of nitrogen gas at 100 kPa and 200 K
(d) 10 g of nitrogen monoxide

12. The sign of ΔH for the process:

$$H_2O(\ell) \rightarrow H_2O(s)$$

(a) is positive and the reaction is endothermic.
(b) Is positive and the reaction is exothermic.
(c) is negative and the reaction is endothermic.
(d) is negative and the reaction is exothermic.

13. Which of the following statements about the effect of a catalyst is **false**?

(a) A catalyst increases the proportion of particles possessing sufficient energy to react.
(b) A catalyst boosts the energy of reactants, enabling to collide with enough energy to react.
(c) A catalyst provides an alternative reaction pathway.
(d) A catalyst is not consumed in a reaction.

14. Which of the following lists the 1 mol L^{-1} solutions in order of **increasing** pH?

(a)	$CH_3COOH(aq)$	$NH_4C\ell(aq)$	$NaC\ell(aq)$	$CH_3CH_2NH_2(aq)$
(b)	$CH_3COOH(aq)$	$NaC\ell(aq)$	$NH_4C\ell(aq)$	$CH_3CH_2NH_2(aq)$
(c)	$CH_3CH_2NH_2(aq)$	$NaC\ell(aq)$	$NH_4C\ell(aq)$	$CH_3COOH(aq)$
(d)	$NH_4C\ell(aq)$	$CH_3COOH(aq)$	$CH_3CH_2NH_2(aq)$	$NaC\ell(aq)$

15. During an experiment to establish the concentration of an oxalic acid solution,Tristan carried out the following steps.

- Rinsed a burette with distilled water.
- Rinsed a conical flask with distilled water.
- Filled the burette with a standardised sodium hydroxide solution.
- Rinsed a pipette with the solution of oxalic acid.
- Dispensed 25 mL of oxalic acid into the conical flask using the pipette.

What effect would this procedure have had on the accuracy of his results?

(a) The volume of sodium hydroxide needed to reach the end point is larger than it should have been so the calculated concentration of oxalic acid would have been too low.
(b) The volume of sodium hydroxide needed to reach the end point is smaller than it should have been so the calculated concentration of oxalic acid would have been too low.
(c) The volume of sodium hydroxide needed to reach the end point is larger than it should have been so the calculated concentration of oxalic acid would have been too high.
(d) The volume of sodium hydroxide needed to reach the end point is smaller than it should have been so the calculated concentration of oxalic acid would have been too high.

SEE NEXT PAGE

16. What would be the **most** likely pH of a 0.10 mol L^{-1} solution of sulfuric acid?

    (a) Less than 0.5
    (b) Between 0.5 and 1
    (c) Exactly 1
    (d) Approximately 1.5

The next three questions (17, 18 and 19) refer to the following reaction between phosphorus trichloride and chlorine to form phosphorus pentachloride:

$$P\ell_3(g) + C\ell_2(g) \rightleftharpoons P\ell_5(g) \qquad \Delta H = -124 \text{ kJ mol}^{-1}$$

17. If phosphorus trichloride and chlorine were placed in a sealed insulated vessel together with a catalyst, which of the following would **not** cause an increase in the rate at which equilibrium would be attained?

    (a) Increasing the volume of the vessel
    (b) Increasing the temperature
    (c) The addition of chlorine to the reaction mixture
    (d) Increasing the state of sub-division of the catalyst

18. Which of the following statements is/are **true** when the system is at equilibrium?

    (i) Reactants are no longer turning into products.
    (ii) The concentration of chlorine in the vessel is constant.
    (iii) Adding a catalyst would not affect the proportions of the reaction mixture.

    (a) (iii) only
    (b) (i) and (ii) only
    (c) (ii) and (iii) only
    (d) (i), (ii) and (iii)

19. After the system has reached equilibrium a little phosphorus trichloride is added at constant temperature to the equilibrium mixture. Which of the following changes would **not** be observed as the system re-adjusts and moves towards a new equilibrium position?

    (a) The reverse reaction would speed up.
    (b) The concentration of PCl_5 would increase.
    (c) The mass of chlorine in the vessel would fall.
    (d) The value of the equilibrium constant, K, would fall.

20. Which of the following equations does **not** represent a redox reaction?

    (a) $Mg(s) + 2\,HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$
    (b) $Mg(OH)_2(s) + 2\,CH_3COOH(aq) \rightarrow Mg(CH_3COO)_2(aq) + 2\,H_2O(\ell)$
    (c) $Sn^{2+}(aq) + Zn(s) \rightarrow Sn(s) + Zn^{2+}(aq)$
    (d) $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$

SEE NEXT PAGE

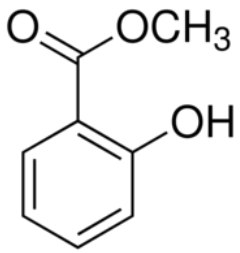
21. A piece of cobalt is placed into a solution of copper(II) sulfate. Which of the following statements is **false**?

    (a) Copper is precipitated.
    (b) There is no change in the number of charged particles in solution.
    (c) Cobalt dissolves.
    (d) Copper ions are oxidised.

22. Which of the following metals, when placed in a solution of nickel(II) sulfate, would cause the solution to fade from green to colourless?

    (a) Lead
    (b) Zinc
    (c) Chromium
    (d) Iron

23. Consider the following molecule, commonly known as oil of wintergreen:



oil of wintergreen

Which of the following statements about oil of wintergreen is **false**?

    (a) It can be synthesised using methanol as one of the starting materials.
    (b) It is an aldehyde.
    (c) It is unsaturated.
    (d) It is an ester.

24. Which of the following molecules can be classified as secondary alcohols?

    (i) 2-methylpropan-2-ol
    (ii) 3-methylbutan-2-ol
    (iii) CH_3CHO
    (iv) CH_3COCH_3

    (a) (i) and (ii) only
    (b) (ii) only
    (c) (ii), (iii) and (iv) only
    (d) (ii) and (iv) only

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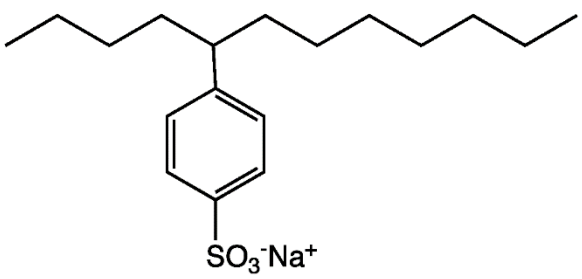
25. The following formula represents the structure of a compound commonly used as a detergent:



Which of the following statements about detergents is **false**?

(a) They are often preferred to soaps because of their low tendency to form scums with hard water.
(b) Part of the molecule is highly water-soluble.
(c) They are the sodium salts of carboxylic acids.
(d) The molecules contain large non-polar regions that can form strong intermolecular forces with fats.

END OF PART 1

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PART 2 Short Answer (70 marks)

This part contains **nine (9)** questions. Answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

Suggested working time: 60 minutes.

Question 1 **(7 marks)**

For each of the following pairs of substances, provide details of a **chemical** test that would allow the two substances to be distinguished from one another. Equations are **not** required. Use of pH indicators is not considered to be a chemical test.

substances	chemical test	observations
Ni(s) and Mg(s)		**Ni(s)**
		Mg(s)
$NaCH_3COO(s)$ and $NaC\ell(s)$		**$NaCH_3COO(s)$**
		$NaC\ell(s)$

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Question 2 **(8 marks)**

(a) 2-methylpropanal, whose formula is $(CH_3)_2CHCHO$, has two structural isomers. In the spaces provided below, draw the full structures showing all H-atoms and give the IUPAC names of these two isomers. (4 marks)

structure	IUPAC name

2-methylpropanal can be converted into substance Y by heating it with a mixture of sodium dichromate and dilute sulfuric acid.

(b) State an observation that can be made as this reaction proceeds. (1 mark)

_____

_____

(c) Name the functional group present in substance Y that is **not** present in 2-methylpropanal. (1 mark)

_____

(d) Write a balanced <u>half-equation</u> showing the conversion of 2-methylpropanal into substance Y (2 marks)

_____

_____

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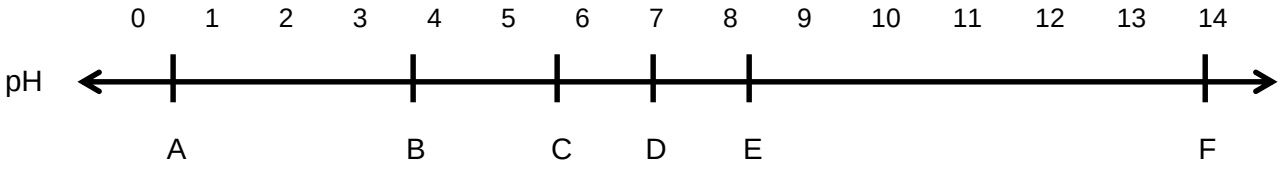
Question 3 **(6 marks)**

Universal indicator was used to measure the pH of six solutions (each with a concentration of 0.5 mol L^{-1}) and the results are shown in the diagram below.



The six substances were;

KCl HF HCl NH_4Cl KOH KF

(a) Which substance is most likely to be C? Explain your answer using an equation. (2 marks)

_____

_____

_____

(b) Which substance is most likely to be F? Explain your answer using an equation. (2 marks)

_____

_____

_____

(c) Name the two substances that would produce a buffer when mixed together. Explain your choice. (2 marks)

_____

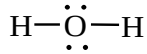
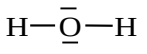
_____

_____

SEE NEXT PAGE

Question 4 **(9 marks)**

For each species listed in the table below, draw the electron-dot diagram or Lewis structure, representing all valence shell electron pairs either as : or as — **and** state or sketch the shape of the species.

(for example, water  or  or  bent, polar)

Species	Lewis structure (showing all valence electrons)	Shape (sketch or name)
phosphorus trichloride $PC\ell_3$		
ethyne C_2H_2		
nitrate ion NO_3^-		

SEE NEXT PAGE

Question 5 **(8 marks)**

Mitch and Jarrod were carrying out a titration in order to determine the concentration of a sodium hydroxide solution. A 20.0 mL aliquot of standard 0.0274 mol L^{-1} ethanoic (acetic) acid solution was delivered into a conical flask and titrated against the sodium hydroxide solution. This process was repeated until an accurate average titre could be obtained.

(a) What piece of equipment would have been used to deliver the aliquots of standard ethanoic acid into the conical flask? (1 mark)

_____

(b) What substance should Mitch use for the final rinsing of his burette just prior to it being used? (1 mark)

_____

(c) Write the equation for the reaction that would have taken place inside the conical flask, including in your answer only those species that react. (2 marks)

_____

(d) Name an appropriate indicator for this titration. Explain your choice clearly. (2 marks)

_____

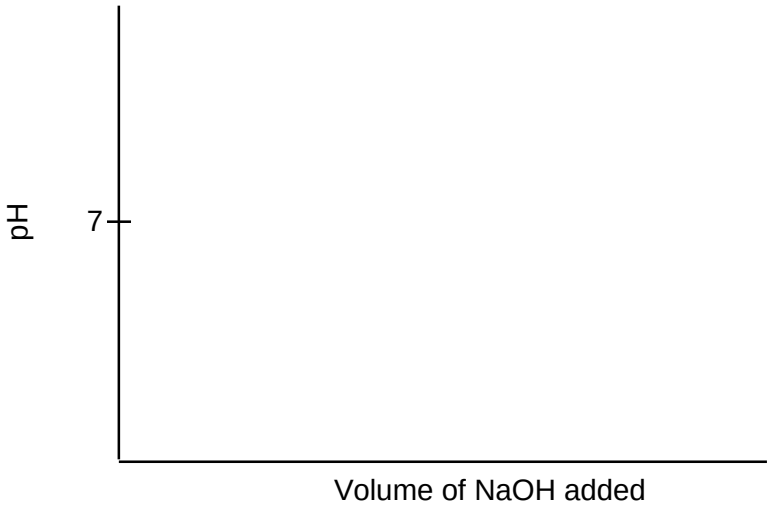
_____

_____

_____

(e) Sketch a titration curve for the above experiment. Label the equivalence point of the reaction.

(2 marks)



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Question 6 **(6 marks)**

Carbonyl bromide ($COBr_2$), also known as bromophosgene, can be produced when the chemicals in fire extinguishers decompose. The following equation represents the endothermic decomposition of carbonyl bromide into carbon monoxide and bromine.

$$\underset{\textit{colourless}}{COBr_2\,(l)} \leftrightarrows \underset{\textit{colourless}}{CO\,(g)} + \underset{\textit{red}}{Br_2\,(g)}$$

(a) Draw the structural formula for carbonyl bromide, representing all valence shell electron pairs either as : or – . (1 mark)

(b) Write the equilibrium constant expression for the decomposition equation. (1 mark)

(c) Complete the following table by indicating the direction of the expected shift in equilibrium immediately following the change stated in the table. Give expected observations in each case. (4 marks)

Change	Direction of shift in equilibrium ('left', 'right' or 'no change')	Observations
temperature increase		
reduce the volume of the container		

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Question 7 **(8 marks)**

(a) But-1-ene and but-2-ene are isomers of C_4H_8. What is the name given to this type of isomerism? (1 mark)

_____

(b) In addition to the type of isomerism displayed by the molecules in part (a), but-2-ene itself exhibits another type of isomerism. State the name given to this type of isomerism, and draw and name the two isomers. (4 marks)

_____

_____

_____

(c) In the space provided, draw a length of polymer chain that could be formed from 2-butene, showing **three** repeating units. (2 marks)

(d) State the name given to the type of polymerisation described in part (c). (1 mark)

_____

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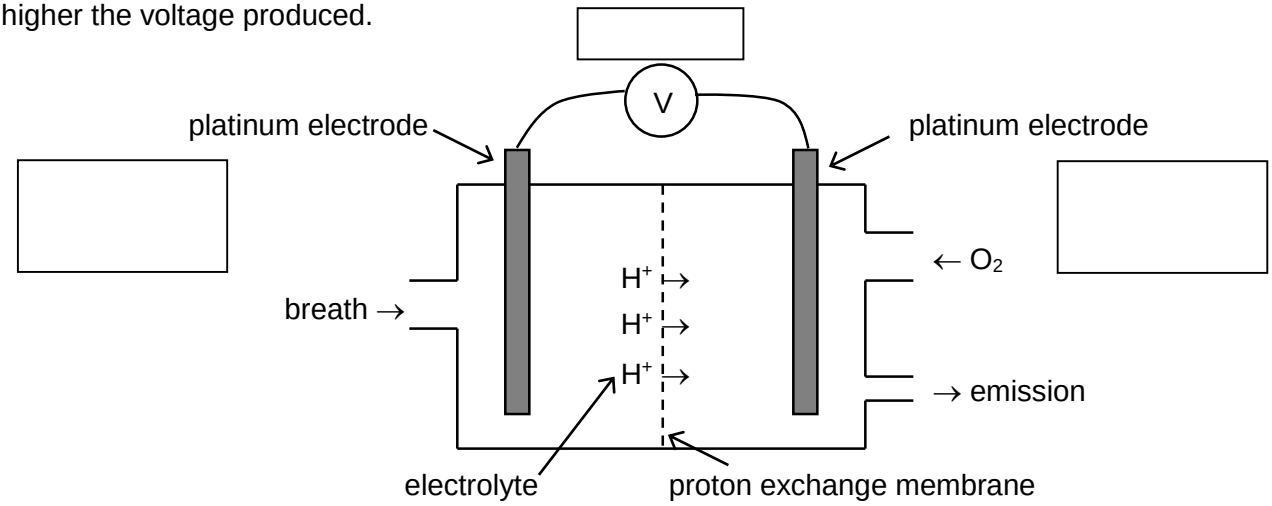
Question 8 **(8 marks)**

One method that can be used to determine blood alcohol level is using an electrochemical cell based on the design shown below. The more alcohol (ethanol) present in the person's breath, the higher the voltage produced.



(a) In the boxes on the diagram above, label the cathode and anode, the charge of each electrode, and the direction of electron flow. (3 marks)

The relevant half equations for the cell, along with their E^0 values under standard conditions are shown below.

$CH_3COOH\ (l) + 4\ H^+\ (aq) + 4\ e^- \leftrightarrows CH_3CH_2OH\ (l) + H_2O\ (l)$ E^0 - 0.67 V

$O_2\ (g) + 4\ H^+\ (aq) + 4\ e^- \leftrightarrows 2\ H_2O\ (l)$ E^0 +1.23 V

(b) What is the purpose of the platinum electrodes? (1 mark)

_____

_____

(c) Write an overall equation for the cell. (1 mark)

_____

(d) Calculate the emf of the cell under standard conditions. (1 mark)

_____

A variation of the 'breathalyser' cell above could involve breathing into a tube containing absorbent paper that is soaked in an acidified potassium dichromate solution.

(e) What colour change would you expect to observe if alcohol was present on someone's breath? (1 mark)

_____

(f) Why are dichromate solutions usually acidified in redox reactions? (1 mark)

_____

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Question 9 **(10 marks)**

Tetrafluoroethene is produced industrially by a series of reactions, the final of which is shown below.

$$2CHClF_2\ (g) \leftrightarrows C_2F_4\ (g) + 2HCl\ (g)$$

(a) What conditions of pressure (high or low) would favour a high yield of tetrafluoroethene? Explain your answer. (3 marks)

_____

_____

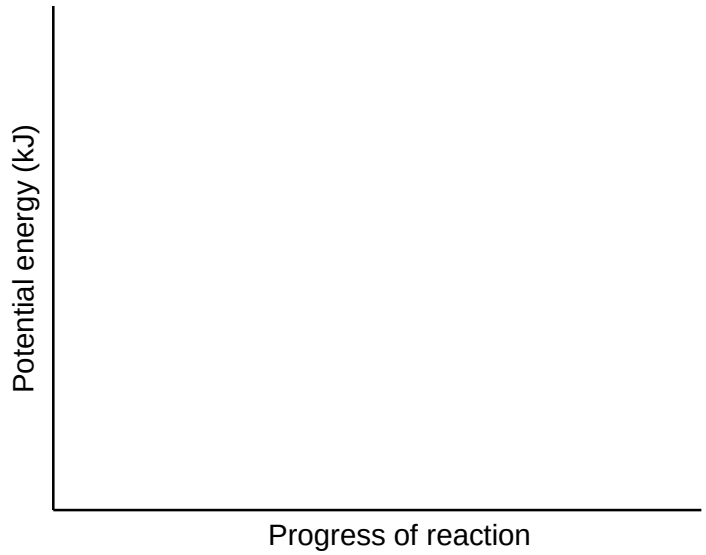
_____

_____

_____

As temperature increases, the concentration of tetrafluoroethene in the system decreases.

(b) Sketch a potential energy diagram for the above reaction. Label the activation energy, reverse activation energy, and the enthalpy change. (4 marks)



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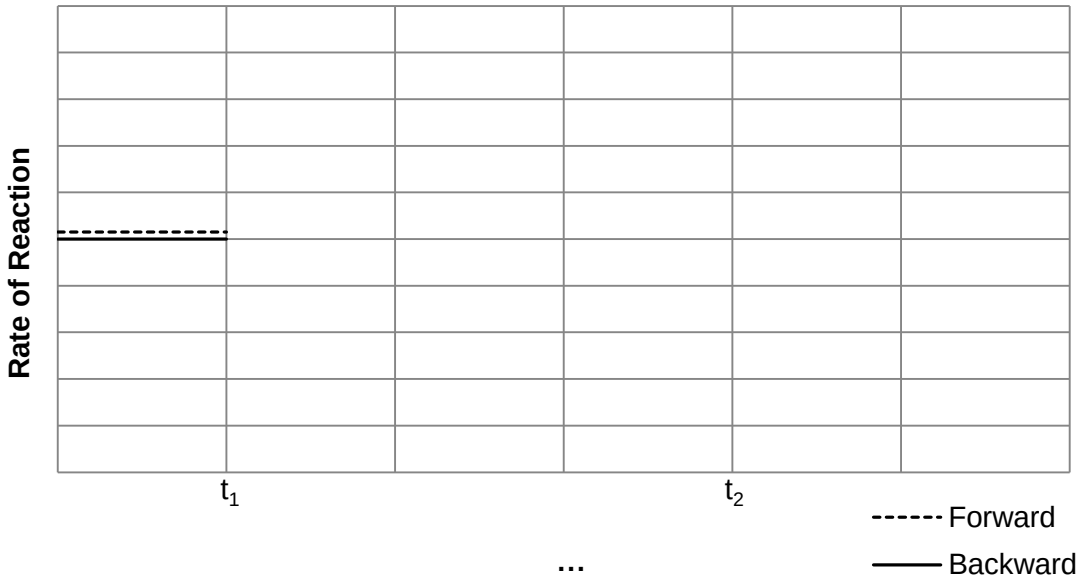
(c) On the axes shown below, sketch the effect of cooling the reaction mixture at time (t_1) on the rates of the forward and backward reactions until the system returns to a new equilibrium at time (t_2).

(3 marks)



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End of part two

PART 3: Extended answer **(80 Marks)**

This part contains **five** questions. You must answer **all** questions. Write your answers in the spaces provided.
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 65 minutes.

Question 1 **(13 marks)**

Chlorine is found in a variety of different acids. Some of these acids are strong acids and some are weak. Chlorine can also exist in different oxidations states. A selection of these acids is shown in the table below.

Name and formula of acid	Strong/Weak
hydrochloric acid $HC\ell$	strong
hypochlorous acid $HOC\ell$	weak
chlorous acid $HC\ell O_2$	weak
chloric acid $HC\ell O_3$	strong
perchloric acid $HC\ell O_4$	strong

(a) What mass of perchloric acid would need to be dissolved in 250 mL of distilled water to produce a solution with a pH of 3.59? (3 marks)

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1.20 g of solid calcium hydroxide was added to a beaker containing 200 mL of a 0.160 mol L^{-1} aqueous solution of chloric acid, and the solution stirred until the reaction is complete.

(b) Write the balanced ionic equation to show the reaction taking place in the beaker. (2 marks)

(c) Determine the limiting reagent by calculation. Show your reasoning. (4 marks)

(d) Calculate the pH of the resulting solution. (4 marks)

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Question 2 **(17 marks)**

Solutions of iron(II) salts are often used in redox titrations, but can be unreliable as the Fe^{2+} ions can be oxidised by oxygen in the environment, forming various hydrated forms of iron(III) oxide, according to the following equation:

$$Fe^{2+}(aq) + O_2(g) + (2x + 4)\, H_2O(\ell) \rightleftharpoons 2\, Fe_2O_3.xH_2O(s) + 8H^+(aq)$$

Ammonium iron(II) sulfate, or Mohr's salt, is often preferred over iron(II) sulfate for redox titration purposes since the unwanted oxidation of Fe^{2+} is prevented by the ammonium ions present, which reduce the pH of the solution. Mohr's salt is commonly found in hydrated form, as any of a number of salts with the formula $(NH_4)_2Fe(SO_4)_2.\ xH_2O$.

(a) Write an equation to show how the ammonium ions are able to lower the pH of the solution. (2 marks)

_____

(b) Using the initial equation given above explain why the oxidation of Fe^{2+} is prevented in solutions of low pH. (2 marks)

_____

_____

_____

_____

10.0 g of hydrated ammonium iron(II) sulfate crystals were dissolved in distilled water and made up to 250 mL in a volumetric flask. 25.0 mL aliquots of this solution were titrated against acidified 0.0240 mol L^{-1} potassium permanganate solution until consistent results were obtained. The table below shows the results of the experiment.

	Rough	**1**	**2**	**3**	**4**
Final volume (mL)	23.00	21.25	21.25	22.65	23.35
Initial volume (mL)	0.00	0.05	0.00	0.10	2.10
Titre (mL)					

(c) Complete the table and calculate the average titre volume. (1 mark)

Average titre: _____

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(d) Write a balanced ionic equation for the reaction taking place between Fe^{2+} and MnO_4^- (2 marks)

(e) Calculate the value of x in the formula $(NH_4)_2Fe(SO_4)_2.xH_2O$. (10 marks)

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Question 3 **(22 marks)**

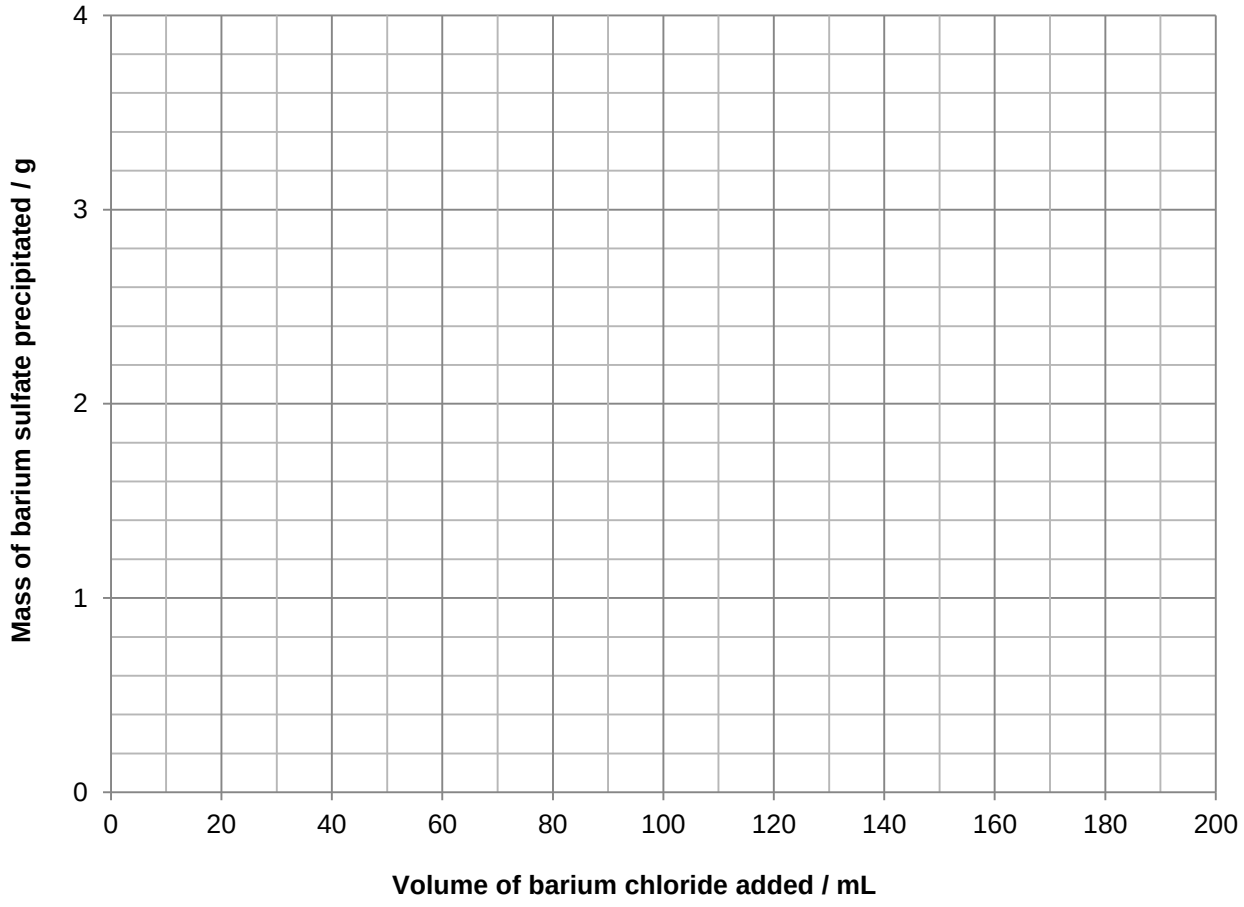
A sample of powdered magnesium sulfate is known to have been contaminated with sodium chloride. The percentage purity of the magnesium sulfate can be determined by the following method:

- 32.50 g of the impure magnesium sulfate is dissolved in water and the solution is made up to 500.0 mL in a volumetric flask.
- Six 20.0 mL aliquots of this solution are placed in separate conical flasks.
- Different volumes of 0.100 mol L^{-1} $BaC\ell_2(aq)$ are added to each flask, causing any sulfate ions present to precipitate out of the solution.
- The precipitate from each sample is filtered, rinsed with distilled water and then dried to constant mass.

The results of this analysis are shown in the table below.

Sample	**1**	**2**	**3**	**4**	**5**	**6**
Volume of $BaC\ell_2$(aq) added (mL)	30.0	60.0	90.0	120.0	150.0	180.0
Mass of $BaSO_4$(s) precipitated (g)	0.61	1.23	1.83	2.04	2.04	2.04

(a) Display the results in a suitable format using the axes provided. (2 marks)



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(b) Write a balanced ionic equation for the reaction taking place. (1 mark)

(c) Explain why the mass of precipitate remained constant for the last three samples even though more barium chloride was being added. (1 mark)

(d) Use the mass of precipitate to calculate the percentage purity of the magnesium sulfate. (5 marks)

(e) Use the graph you have drawn in part (a) to estimate the minimum volume of barium chloride needed to precipitate all the sulfate ions from solution. (1 mark)

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Question 3 (continued)

(f) Calculate the final, total concentration (in mol L^{-1}) of chloride ions in the filtrate collected from **sample four**. You may assume that sodium chloride was the only impurity present in the impure magnesium sulfate. (7 marks)

(g) Another student carried out a similar analysis, but neglected to rinse the precipitates before drying them. Explain clearly what effect this would have on the student's calculated value of the percentage purity. (3 marks)

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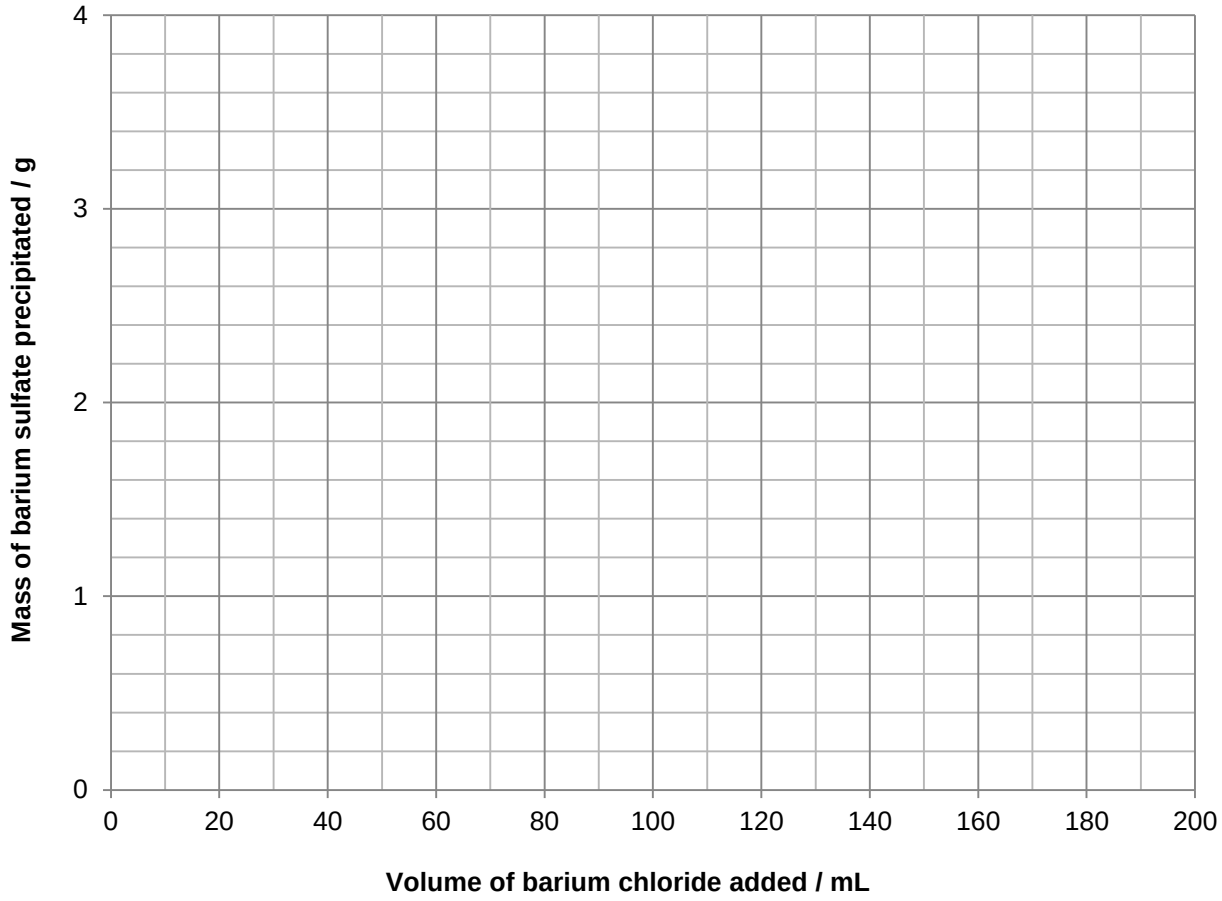
The analysis was repeated using six further 20 mL aliquots of the impure magnesium sulfate solution and the same volumes of barium chloride. However, the concentration of the barium chloride solution used was 0.200 mol L^{-1}.

(h) Using the axes below, draw the graph of the expected results when plotting the mass of barium sulfate precipitated against volume of barium chloride added. (2 marks)



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Question 4 **(17 marks)**

The European Aviation Safety Agency (EASA) have recently sponsored studies into ultra-low sulfur jet (ULSJ) fuel standard. It is estimated that, by reducing the amount of sulfur in jet fuel, between 1000 and 4000 pollution-related deaths could be prevented globally each year.

However, the cost to the aviation industry would be between $1 billion and $4 billion per year, which equates to an increase in the cost of jet fuel of around 2%. It is also believed that reducing the amount of sulfates in the atmosphere (produced by the burning of jet fuel), would actually cause warming of the planet to increase.

Sulfur is present in fossil fuels in the form of sulfur-containing organic compounds, such as dibenzothiophenes. Analysis of one such compound showed that it was made up only of the elements carbon, hydrogen and sulfur. Upon combustion in excess oxygen, a 22.60 g sample of the compound was found to produce 8.85 g of water vapour and 77.9 L of carbon dioxide, measured at 1000°C and 200 kPa.

(a) Calculate the **empirical formula** of the compound. (8 marks)

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Another sample of the compound, weighing 10.71 g, was vapourised in the absence of oxygen. The vapours occupied 1.265 L at 200 kPa and 250°C.

(b) Use this information and your answer to part (a) to calculate the **molecular formula** of the compound. (3 marks)

The ULSJ fuel standard is equivalent to a concentration of sulfur 15 ppm (parts per million).

(c) Calculate the concentration of sulfur in ULSJ fuel in mol L^{-1} if 1L of the fuel weighs 800 g. (3 marks)

One of the problems associated with the presence of sulfur in fuels is that as rain falls through oxides of sulfur in the atmosphere, they react with the rain. The effect is that the rain becomes acidic.

(d) With the help of equations, explain how these oxides can cause rainwater to become acidic (3 marks)

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Question 5 **(11 marks)**

The functional groups present in organic molecules can, by definition, have a strong influence on the chemical properties of those molecules, but they can also play a role in determining the physical properties of substances.

The table below outlines some of the physical properties of four organic substances; pentane, 2,2-dimethylpropane, 2-pentene, and propanoic acid.

	boiling point (°C)	**solubility in water**	**solubility in ethanol**
pentane	36.1	low	high
2,2-dimethylpropane	9.5	low	high
pent-2-ene	37.0	low	high
propanoic acid	144.1	high	high

With clear reference to the structure and bonding present, compare and contrast the **chemical and physical properties** of the four substances. You should focus on the physical data provided in the table for the physical properties and use your knowledge of the organic chemistry of the compounds for the chemical properties.

Your answer should include equations where appropriate.

Marks are awarded for clarity of communication. Answers may be written as a series of dot points and diagrams may be used, but care should be taken to ensure that there is a logical sequence of ideas and that any abbreviations or diagrams are explained clearly.

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